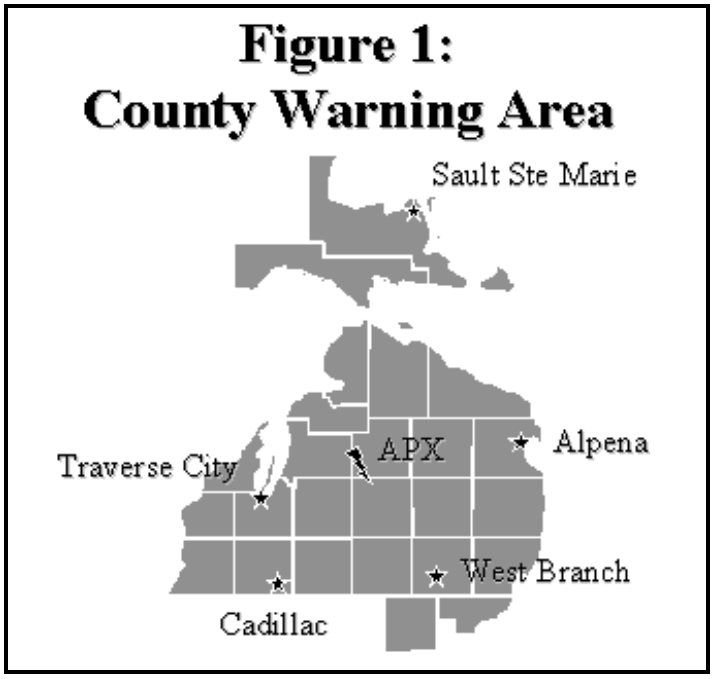
Introduction

Tornadoes are among nature's most feared and destructive phenomenon. Consequently, it is the mission of the National Weather Service (NWS) to provide forecasts and warnings for the protection of life and property. Knowledge of when and where tornadoes are likely to develop can help NWS meteorologists better anticipate an event before storms develop.

The Gaylord, Michigan NWS office (APX) was opened in 1994 as part of the modernization of the National Weather Service. APX services an area of approximately 14,700 sq mi including the communities of Alpena, Sault Ste. Marie, Traverse City and West Branch. Since 1970, the population of northern Michigan has increased from approximately 366,000 to 600,000 in 2000 according to the United States Census Bureau. This study was conducted across the APX County Warning Area (Fig 1) which encompasses 25 counties across eastern Upper Michigan and northern Lower Michigan.

Figure 1: County Warning Area



1. Explanation of Data

The official source of all climatological information in the United States is the National Climatic Data Center (NCDC). NCDC produces a publication called Storm Data which is composed of all storm reports received for a particular month. The information regarding tornado history in northern Michigan was taken from the Storm Data database. Supplemental data was obtained through the Storm Prediction Center's (SPC) database along with Grazulis Significant Tornadoes. Various limitations to the data have been documented in previous studies (Kelly et al. 1985; Hales 1993). The number of reports tends to be affected by population, spotter density, time of day and the motivation of an office to verify warnings.

Data collected from NCDC often lacked a description, or narrative, of the event. For this reason, area newspapers and libraries were sent letters asking for additional information about the tornadoes. Libraries and newspapers who responded to our request are listed in Appendix A.

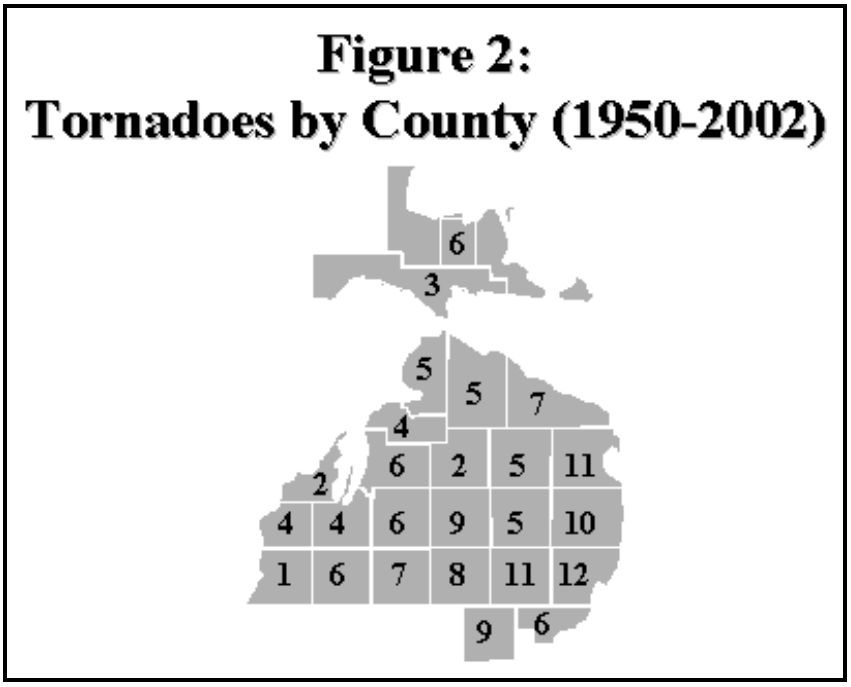
Tornado intensity is described by the F-scale (Fujita 1981). In this paper, weak tornadoes are

considered F0 or F1 and stronger tornadoes are those that are greater than F2. A detailed description of the Fujita scale can be seen in Appendix E. Tornado times are in Eastern Standard Time (EST). A tornado day is defined as a 24-hour period (midnight to midnight) in which at least one tornado occurs. In this paper, a tornado event is defined as a tornado that may or may not have crossed county boundaries but is counted as one tornado.

Ostby (1993) documented that since 1980 there has been a distinct increase in weak (F0-F1) tornadoes, while the number of stronger tornadoes has remained relatively constant. This has been attributed to NWS verification, storm spotter efforts and an increase in population.

A total of 154 tornadoes were recorded between 1950 and 2002. Data prior to 1950 was not included in this study because reports were sporadic and not available from Storm Data. During the 52 year period of this study, 154 tornado events occurred, or about 3 tornadoes per year. The average number of tornadoes over that same time period for the state of Michigan is sixteen.

3 General Characteristics of northern Michigan Tornadoes



A county by county plot of tornado reports (Fig 2) indicates that generally the southeastern portion of the APX CWA has recorded the greatest number of tornadoes. The exceptions are Oscoda and Arenac counties which possess a lower population density as compared to its neighboring counties.

One possible explanation for the fewer tornadoes across northwest Lower Michigan is that the marine influence of Lake Michigan tends to suppress tornadoes, especially in the spring and early summer months when lake temperatures are relatively cool.

A possible reason for a greater number of tornadoes in the southeast is the interaction of lake breezes with thunderstorms over those counties. Lake breezes can impact convection in two ways. First, they

can help initiate convection by providing a lifting mechanism. Second, they can affect the low-level wind field in such a fashion as to increase the amount of shear which would result in a more favorable environment for tornado formation.

A plot of tornado tracks (Fig 3) shows that most tornadoes move from southwest to northeast. Again, note that the majority of tornado reports occur in the southeastern portion of the APX CWA. (The SPC Storm Track Database does not contain all of the tornadoes found in our database. The graphic below does however contain the vast majority of those tornadoes and has for that reason been reproduced here.)

Figure 3:
SPC Storm Track Database

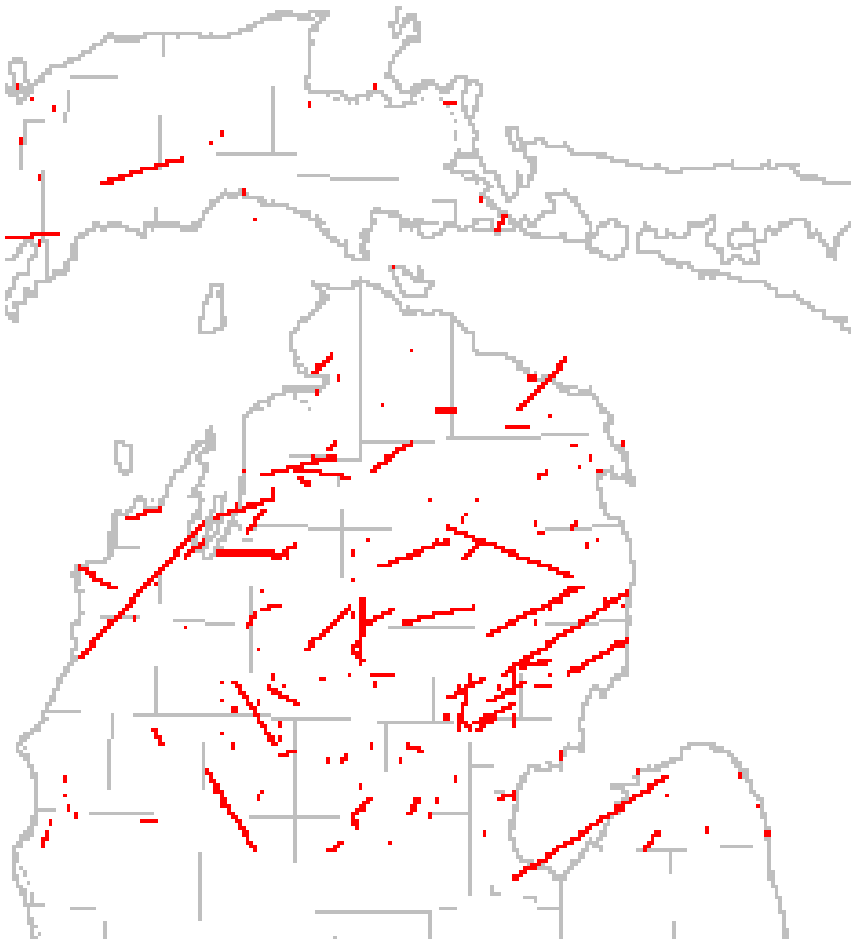


Figure 4:
Yearly Distribution of Tornado Events and Tornado Days (1950-2002)

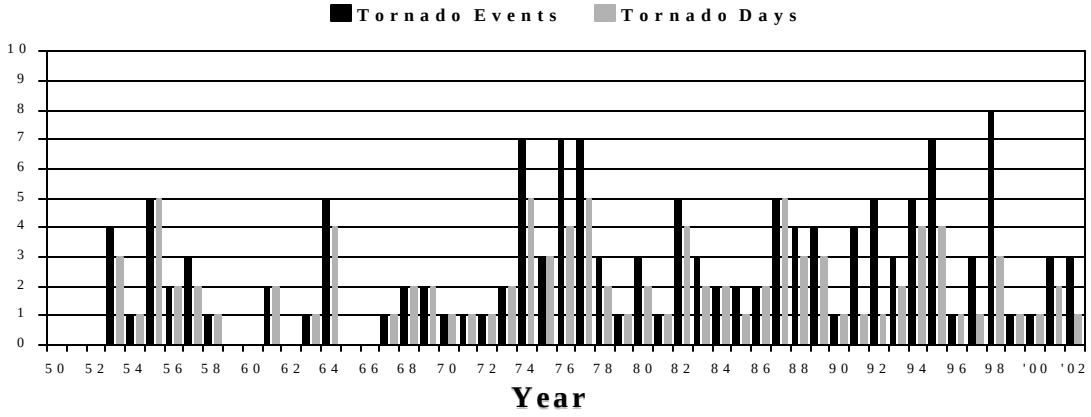


Figure 4 shows that there has been an overall increase in the number of tornado reports since 1970. Possible explanations include the implementation of warning verification by the National Weather Service, a more active spotter program, as well as an increase in population.

Figure 5 indicates that the increase has been focused at the F0/F1 intensity scales, while there has been no significant increase in F2 or higher tornadoes. F-scales are a reference to the Fujita scale, a scale in use by the NWS to categorize tornado intensity, see Appendix E for more information. This observation is consistent with other tornado climatology studies (Otsby 1993).

Figure 5:
Tornadic Intensity
as a Function of Time

	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89	90-94	95-99	00-02
F0	1	2	1		2	2	8	7	3	7	6
F1	2	6	2	3	4	9	5	11	10	7	1
F2	1	2	5		5	6	1		2	3	
F3	1			1	1	2			3		
F4		1									
Total #	5	11	8	4	12	19	14	18	18	17	7
Avg F-scale	1.4	1.3	1.5	1.5	1.4	1.4	0.5	0.6	1.3	0.8	0.1

Figure 6:
Monthly Distribution of Tornado Events and Tornado Days (1950-2002)

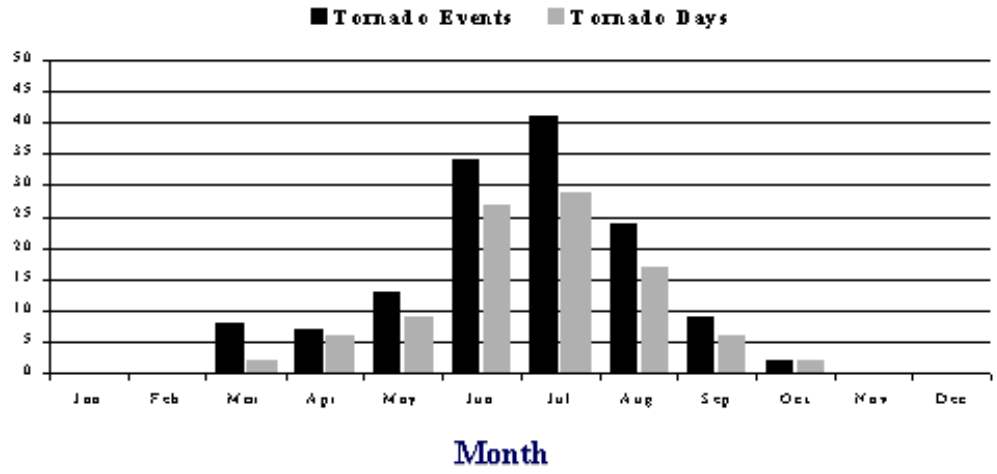
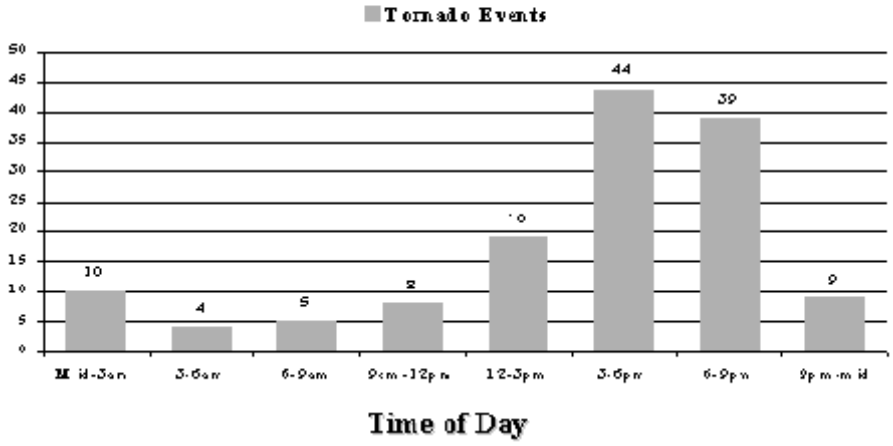


Figure 6 indicates the tornado season for northern Michigan extends roughly from March through October. The most active months are June and July in which approximately 55% of tornadoes occur. No tornadoes have been reported in northern Michigan from November through February, though tornadoes have occurred in every month of the year in the state of Michigan.

Figure 7:
Three-Hourly Distribution of Tornado Events (1950-2002)



A three hour distribution of tornadoes (Fig 7) indicates that almost 60% of tornadoes occur between 3 and 9 pm. This coincides with the peak of the diurnal instability cycle.

4 Conclusions

Since 1950, 154 tornadoes have been recorded across northern Michigan. This equates to about three per year. There has been an increase in the number of tornadoes since 1970. This increase has been focused at the F0 and F1 tornado intensity scales, while the number of F2 and stronger tornadoes has remained relatively unchanged. This increase can be largely attributed to improved verification efforts by the NWS, storm spotter efforts and an increase in the population.

The northern Michigan tornado season runs from March into October with the most active period occurring during June and July. No tornadoes have been reported in northern Michigan during the winter months from November through February; however, tornadoes have been reported elsewhere in Michigan during those months.

The most active time of the day for tornadoes is during the late afternoon and early evening when the diurnal instability cycle is at its peak. In terms of spatial variability, the southeastern portion of the Gaylord National Weather Service forecast area tends to be the most active. One possible explanation for this observation is that the marine environment near Lake Michigan may act to suppress tornado development over northwest Lower Michigan. Across the southeast section of the APX CWA a possible reason for a greater number of tornadoes is the interaction of lake breezes as thunderstorms move over those counties.

The purpose of this study was to determine the history (climatology) of tornadoes in northern Michigan. Data was collected for the 25 counties served by the NWS in Gaylord. It is hoped this study will increased awareness of tornadoes in northern Michigan. Although rare, tornadoes do occur and it is hoped that increased awareness will lead to better preparedness in schools, businesses and homes.

Acknowledgments

The authors would like to acknowledge the following libraries and newspapers for their contributions to the paper and many of the tornado descriptions which are found in
Appendix C and D.

Alcona County Review

Alpena County Library

Bayliss Public Library

Benzonia Public Library

Charlevoix Public Library

Elk Rapids District Library

Gerrish-Higgins School District Public Library

Gladwin County Record

Gladwin Public Library

Hillman Public Library

Kalkaska County Library

Leland Township Public Library

Lewiston Public Library

Missaukee Sentinel

Montmorency County Tribune

Oscoda County Library

Otsego County Library

Rose City Historical Society

Traverse Area District Library

West Branch Public Library

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